DIGITALISATION & SOLAR:

Task Force Report

October 2017

SolarPower Europe

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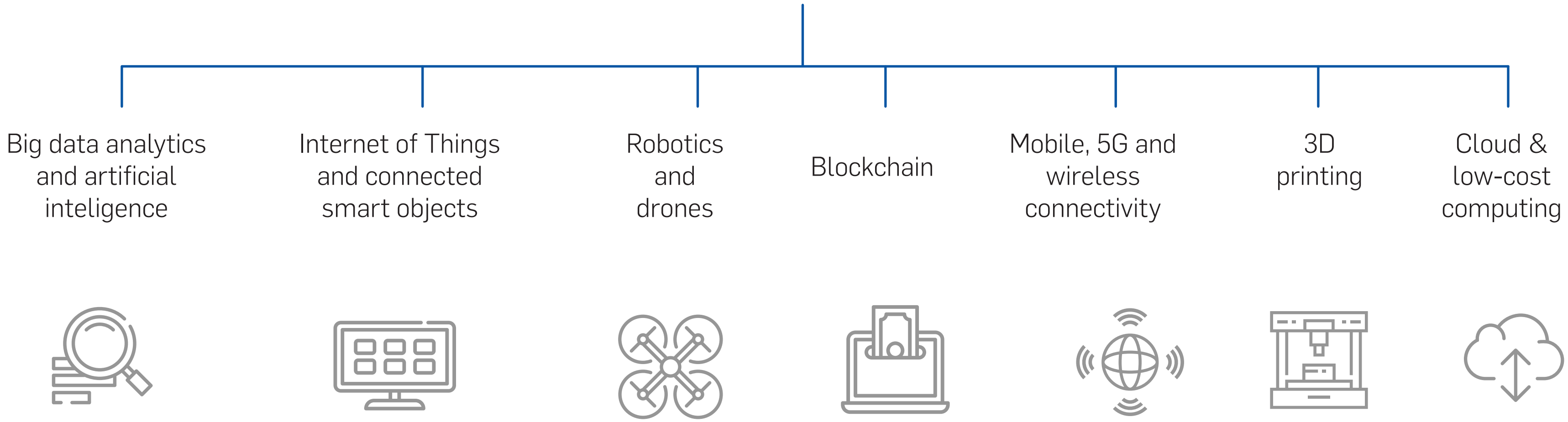
INTRODUCTION

? HOW CAN SOLAR MAKE THE MOST OF THE MARKET OPPORTUNITIES OF DIGITALISATION? HOW CAN DIGITALISATION BE A DRIVER FOR MORE SOLAR DEPLOYMENT? HOW CAN DIGITALISATION IMPROVE AND CREATE NEW SOLAR BUSINESS MODELS?

WHAT IS DIGITALISATION?



Background facts and statistics:

- Analysts have estimated that digital grids could lead to €810billion in extra revenues for renewables between now and 2030. [1]
- Digitalisation could represent up to $1.3trillion of value to the electricity sector as a whole from 2016 to 2025. [2]
- According to some projections we could see 200 billion Internet of Things devices by 2020. [3]
- It is estimated that the volume of controllable smart appliances in the EU by 2025 will be at least 60 GW, which could reduce peak demand by 10%.[4]
- Consumer expectations are changing in all sectors including electricity: they want more choice and comprehensive, seamless, intuitive, personalised, ethical and engaging services.

This is a report of the SolarPower Europe Digitalisation & Solar Task Force.

SECTION I: NEW, IMPROVED AND DIGITALISED SOLAR BUSINESS MODELS

The advent of new technologies such as big data analytics, the internet of things, robotics and blockchain allows for the emergence of entirely new solar business models and for the improvement of existing models, making them more profitable. Increased profitability brings retail and wholesale grid parity that much closer.

INCREASING SELF-CONSUMPTION RATES

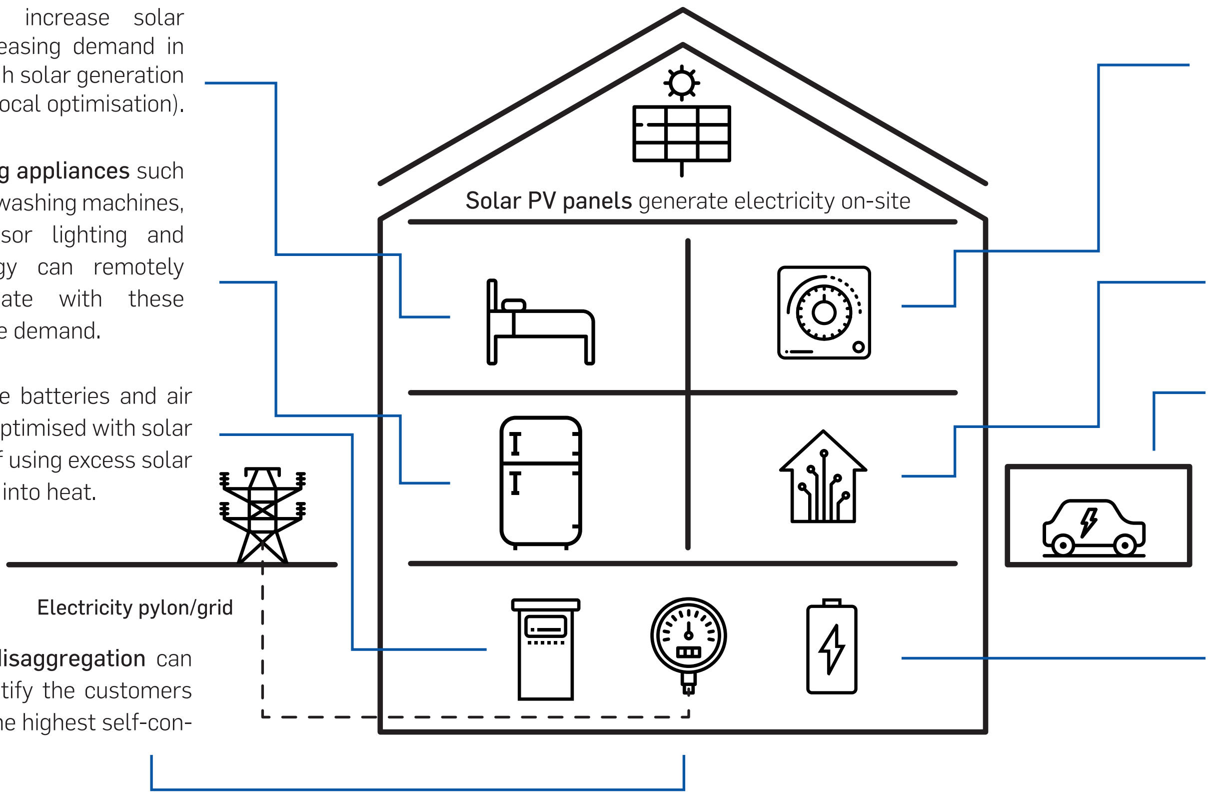
Smart building technology, which can apply to both residential and commercial buildings, can be a major driver of increased self-consumption rates and therefore increase the profitability of self-consumption business models. Looking ahead, solar is likely to be sold as a core part of a smart building package. (Conversely, the drive to self-consume solar electricity is a driver for smart building technology.)

THE SMART BULDING PACKAGE

Demand response can increase solar self-consumption by increasing demand in the building at times of high solar generation and vice versa (known as local optimisation).

Smart automated building appliances such as fridges, tumble dryers, washing machines, dishwashers, motion-sensor lighting and blinds. Digital technology can remotely control and communicate with these appliances to adapt on-site demand.

Heat pumps, heat storage batteries and air conditioning units can be optimised with solar generation and be a way of using excess solar electricity by converting it into heat.



Smart meter data and disaggregation can also be used to help identify the customers that are likeliest to have the highest self-consumption rates.

Smart learning thermostats that are internet connected can be combined with electric heating or cooling. Solar providers in the US are already offering customers free smart thermostats.

Smart building energy management systems which can also provide monitoring, are made possible with wireless communications, advanced data analytics and the Internet of Things.

Smart electric vehicle charging in car parks and the PV4EV 'drive on sunshine' solution could significantly increase self-consumption rates for some households and businesses, especially when combined with storage.

Battery storage is a mutually reinforcing technology when combined with PV. Residential storage can increase solar PV self-consumption rates from approximately 30% to 70% with added system benefits of reducing network and system costs.

Smart home energy managements systems are the key digital technology to increase self consumption rates. Deep machine learning and artificial intelligence can be integrated within these systems to help forecast and manage generation and consumption, as well as voice activation technology. Some energy management systems can optimise not just electricity flows but also heat and electric mobility, achieving sector coupling and full electrification. At present not many energy management systems are advertising the ability to integrate with and optimise solar PV. Those that can will take market share in the solar market. In commercial buildings the ideal scenario would be for these systems to be able to integrate with other facilities management functions in the building.

As regards demand response, aggregators that use remote control technology can also reduce on-site demand and increase grid feed-in at times of high electricity prices (implicit demand response), thereby increasing revenues. Explicit demand response also generates additional revenue by selling flexibility services within wider demand response markets. The current theoretical potential of demand response in Europe is estimated by the European Commission in its Impact Assessment on downstream flexibility at 100,000 MW and is expected to increase to 160,000 MW in 2030.

If smart electric vehicle charging is to be used to increase self-consumption rates, the PV installation size needs to be increased and sized accordingly to the forecast power demand from the vehicle for optimum profitability. Top analysts have described electric vehicles as 'the gateway drug to solar' as intelligent solar charging leads to long-term cost stability for the vehicle user. The reverse is also true: solar can be a gateway drug for electric vehicles, as solar owners look for something to do with excess power. In future vehicle-to-home and vehicle-to-grid integration could also provide valuable grid services and generate revenue.

Finally, smart meter data could make the identification of potential solar customers much more efficient. In the last 5-10 years of solar development door-to-door salesmen often simply knocked on the doors of suitable-looking homes. In the future we could see companies using power disaggregation software to analyse consumption data and use statistical patterns to allocate certain portions of electricity demand to different appliances to pre-identify which customers' demand profiles are the best match for – and can be most shifted to suit - solar PV. If a business customer has high electricity consumption levels between 11am and 3pm, or has demand that could easily be shifted to that time, they are ideal for solar.

WILL 'GAFA' DOMINATE THIS WORLD TOO?

Opinion is divided as to whether the 'GAFA' giants of the tech world (Google, Apple, Facebook and Amazon) will dominate the building energy management system space by incorporating these systems into their platforms, or whether these systems will emerge as platforms in their own right. Given many people already interact with Google, Apple and Amazon on a daily basis, there is a natural pull towards those providers, especially in the residential segment. They are well-positioned to offer a seamless customer experience across different channels. In the commercial segment, we are likely to see other platforms emerge.

Equally important is how interoperable different hardware and software systems will be. It is important that different services do not emerge in separate silos. Nest and Samsung are developing their 'Works with Nest' and 'Works with Samsung SmartThings' smart-home ecosystems. Apple HomeKit, Amazon Echo and Google Home are all potential competitors. Some analysts however have commented that to date these providers have focused more on entertainment systems than energy.

There are also multi-provider platforms such as Mozaiq (a collaboration between ABB, Cisco and Bosch), Wink and If This Then That (IFTT) which consists of small 'applets' that can connect different products and services from different brands. The EEBus initiative, originally funded by the German government, is considered by many to be the strongest interoperability initiative in Europe and has created a 'common language for energy' which is attempting to overcome the highly fragmented array of protocols in the smart home and smart grid space. The Smart Buildings Alliance for Smart Cities, based in France, is also developing its own smart buildings standards called Ready2Services and Ready2Grids.

DO THESE TECHNOLOGIES PAY FOR THEMSELVES?

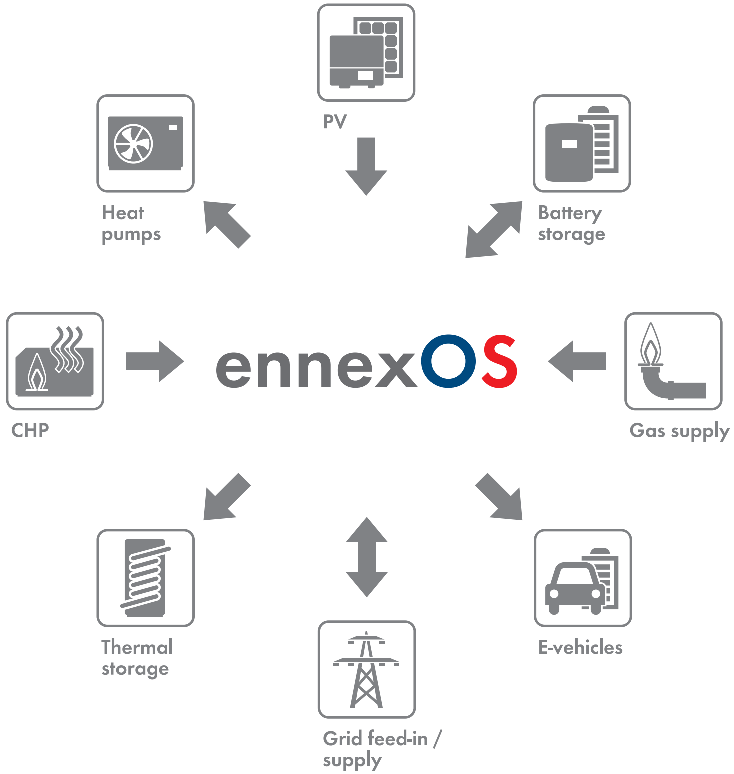
The key question is do these smart home technologies currently increase or decrease the return on investment on an installation when combined with solar? If not yet, when will they? Compared to the total cost of the PV installation, many of these add-on technologies are relatively low cost. Smart thermostats are already advertising paybacks of less than two years on their own, and this could be reduced further when combined with solar and electric heat. Pilot projects have shown that in the medium term the payback period on an energy management system can be less than two years for modern single-family homes with controllable loads.

However at present adding one of these items to a PV system can, in many countries, reduce the payback period on the package as a whole. Previous SolarPower Europe analysis has shown that under current conditions solar-only systems often provide higher rates of return than solar-plus-storage systems[6]. As storage and smart technology costs decrease this will gradually shift and the business case for combining solar with this new technology will be clear.

CASE STUDY:
SMA'S ENNEXOS ENERGY MANAGEMENT PLATFORM OPENING UP NEW OPPORTUNITIES IN THE ELECTRICITY BUSINESS

The digitisation of the energy transition offers excellent opportunities in the form of innovative business models for companies in the renewable energy industry. This is because decentralisation and digitisation complement each other perfectly and turn current energy supply structures upside down. With connected, intelligent energy management solutions and the interlinking of various sectors, SMA is giving the electricity prosumers of the future new possibilities to exploit the full potential of this new energy world.

One example is that of a shopping mall: a big Leclerc supermarket in Bordeaux in the south of France has already been able to cut its electricity costs by approximately €75,000 to date since a 500kW solar carport was installed. Using SMA system technology, the solar power produced is used in the supermarket and shopping mall, covering 15% of its annual demand. Electric charging stations were installed as a bonus. Customers can use them to charge their electric vehicles in the parking lot while they do their shopping. This example is only the beginning. Thanks to targeted energy management, companies and business operators are not only able to make themselves largely independent from utilities, they can also develop new business models. Self-generated solar power can be re-sold using digital interfaces. This allows companies to become electricity traders or part of a virtual power plant consisting of several decentralised power generation plants.



The new energy management platform ennexOS from SMA offers modular solutions for sales support, planning, simulation, configuration and the operation of decentralised energy supply systems. It will be possible for the first time to interlink the various energy sectors thanks to the energy management platform. All energy sources are combined, whether they are sources of generation like PV systems, combined heat and power (CHP) units and heat pumps or sources of demand like heating, air conditioning, cooling and lighting systems. This allows energy flows to be brought into perfect alignment as well as optimising consumption and costs. By incorporating battery storage systems this energy can also be used at any time of day.

SMA

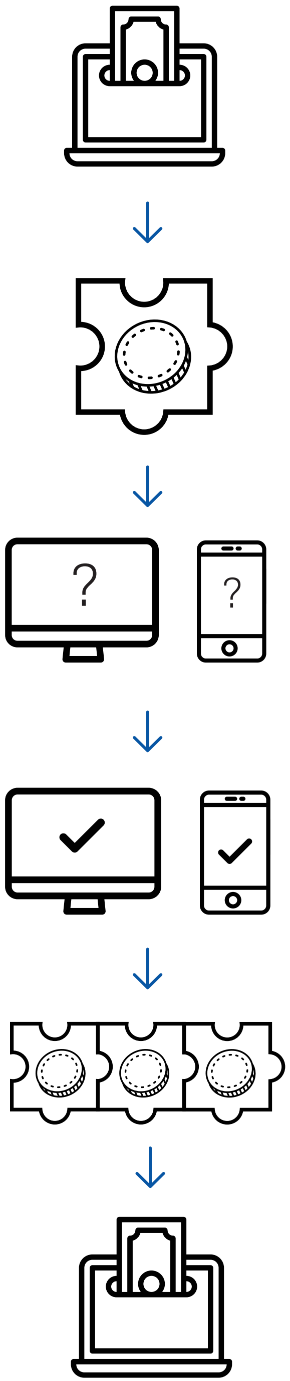
BEYOND FIT AND FORGET: UPSELLING SOLAR WITH ADDITIONAL SERVICES

Up until now many residential and commercial rooftop solar installers have been 'fit and forget' installers, where once connected an install generates little additional value. Some may do ad-hoc operations and maintenance, but this has in the past often been unviable (or unnecessary) with small-scale systems.

In the future thanks to new digital technologies, installation companies could start obtaining extra value by also up-selling related solar services. The reverse is also true: some utilities are already co-selling solar to their customers, part of utilities playing a bigger role with customers in terms of home optimisation and self-generation[7]. And this package of services can be personalised for every consumer - mass personalisation is itself a product of digitalisation. We've seen Software as a Service (SaaS), this is Solar energy as a Service (Seaas) [8] . Examples of such solar services include:

- **Operations & maintenance services** – remote monitoring sensors, wireless communications and software now allows installation and third party providers to offer cost-effective O&M services to small-scale systems.
- **Aggregation services** – with remote controllability, the installer can provide aggregation services[9] for the excess electricity to increase revenues and meet minimum bid sizes in electricity markets. This flexibility can also be remunerated with additional revenue streams from balancing and ancillary services. The exact amount of increase in revenue that can be achieved will vary from country to country, based on existing remuneration and the regulatory framework.
- **Finance** – zero-down solar with 'freemium'-style power purchase agreements made possible by smart metering, leasing financing schemes or loans can increase the potential customer base. Insurance can also be added on as an extra financial product. Digitalisation is also transforming sources of finance, with online crowdfunding communities raising finance for projects in countries where banks are reluctant to lend.
- **Flat rate pay monthly models** – instead of paying per kWh for electricity consumed, customers could be offered a fixed pay monthly price or capped price where a third party works to reduce electricity demand by maximising self-generation and reducing energy consumption. Existing flat rate models currently only guarantee a flat rate within a certain consumption range, and the flat rate is adjusted if consumption goes above or below that. Some flat rate models even include heat and power, guaranteeing pre-determined temperatures in a building.
- **Complementary technology** – see list of smart technology in previous section on increasing self-consumption rates.
- **Energy audits** - energy efficiency improvements and energy audits based on consumption data can further reduce carbon footprint and be co-sold with solar.
- **Residual power supply** – this is defined as the portion of electricity demand that is not supplied by the PV system. This could be enhanced further with a dynamic pricing tariff[10] or if customer has electric vehicle(s) a dedicated 'PV+EV' tariff could be offered. EV-specific time of use tariffs are already available in California [11] .

1. Alice wants to pay Ben for some electricity
2. The first Block is created online and represents the transaction
3. The Block is broadcast to every party in the network
4. The computers in the network approve the transaction and validate it
5. The Block is then added to the Chain which provides a permanent, non-repudiable and transparent record of the transaction
6. Ben receives the money from Alice



BLOCKCHAIN BOX

Providers can also give customers extra value from their PV installations with cryptocurrencies which are based on blockchain technology.. The service provider can allocate the customer with cryptocurrencies designed to apportion additional value to solar or renewable electricity, such as SolarCoin, GENERcoin and EnergyCoin. These cryptocurrencies are usually allocated per MWh of solar electricity produced and can later be converted to Bitcoin and hard currency.

WHAT IS BLOCKCHAIN?

A lack of understanding remains amongst many energy industry players at to what blockchain technology is. In the context of energy PwC define Blockchain as follows:

"A blockchain is a digital contract permitting an individual party to conduct and bill a transaction (e.g. a sale of electricity) directly (peer-to-peer) with another party. The peer-to-peer concept means that all transactions are stored on a network of computers consisting of the computers of the provider and customer participating in a transaction, as well as of the computers of many other network participants. Traditional intermediaries, e.g. a bank, are no longer required under this model, as the other participants in the network act as witnesses to each transaction carried out between a provider and a customer, and as such can afterwards also provide confirmation of the details of a transaction, because all relevant information is distributed to the network and stored locally on the computers of all participants."[12]

Opinion is divided within the solar PV industry as to whether blockchain technology will have a lasting impact on the electricity sector or whether this is a temporary 'hype'. Nevertheless it is important for industry leaders to understand the potential change this technology could bring. It is important to note also that private blockchains are very different to public blockchains with regards to time lag and performance issues.

CASE STUDY:
TESLA: UTILITY IN VERMONT FIRST TO SELL AND AGGREGATE POWERWALLS

TESLA

Today, modern utilities and grid operators are utilizing battery technology like never before. The next step in tapping the potential of energy storage is putting together thousands of batteries to form an energy network that utilities can use to deliver immediate value for the electric system. Tesla can now bundle Powerwall and Powerpack batteries into a single portfolio, also called aggregation, to make the grid cleaner and more efficient. Meanwhile, Powerwall customers who allow Tesla and the utilities to use their battery when energy demand is highest will not only have home backup power, but will also receive compensation for its use on the grid.

Tesla and Green Mountain Power, a utility in Vermont, USA, are working together to bundle Powerwall and Powerpack batteries into a single resource of shared energy for the first time. Green Mountain Power will install Powerpacks on utility land and deploy up to 2,000 Powerwall batteries to homeowners within the utility's service territory, which will enable more renewable energy and increase grid efficiency. Customers will receive backup power to their home for the next 10 years, eliminating the need for traditional backup generators that use fossil fuel. At the same time, Tesla and Green Mountain Power will provide a variety of grid services using the network of installed Powerwall batteries, delivering dynamic capacity and additional grid stability, while sustainably lowering costs for all utility customers. Tesla will also work with Green Mountain Power to dispatch the aggregated resource into New England's wholesale electricity markets, producing additional savings for customers in the region. Tesla is working with energy retailers, grid operators, utilities and aggregators across the globe to unlock the ability for Tesla batteries to deliver grid services while providing reliable power at all times of day. To find out more about how to aggregate Tesla batteries visit tesla.com/utilities.

Results

- Reduction in transmission and distribution costs
- Reduction in peak demand (peak shaving)
- Backup power for participating customers during grid outages
- A leader in creating a sustainable energy future

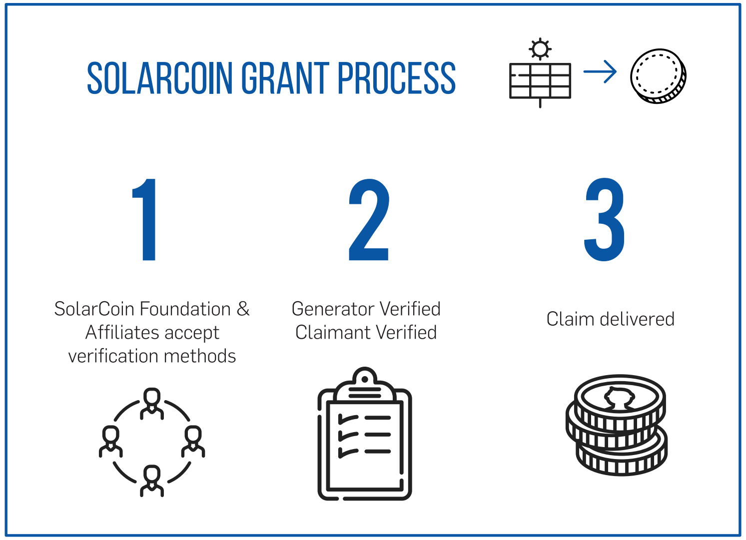
CASE STUDY:
SOLARCOIN: A DIGITAL ASSET TO INITIATE THE GLOBAL ENERGY TRANSITION

SolarCoin is an international and community-based initiative promoting the development of solar energy and self-consumption using one of the most disruptive technologies to have emerged in recent years: blockchain. SolarCoin is like an airmile programme and any solar power producer can connect their solar panels to the SolarCoin network by registering their solar install to the SolarCoin website, receiving 1 SLR (ie SolarCoin, §) for each MWh of solar energy produced.

Blockchain, the technology behind Bitcoin and other digital currencies is a decentralised ledger which allows participants to communicate and validate data and monetary transactions on a same registry, available peer-to-peer to all participants in the network. This can apply to solar energy as well.

SolarCoin uses blockchain technology to generate a decentralised, incorruptible and auditable record of solar energy produced by any solar owner and comes in addition to government-backed subsidies.

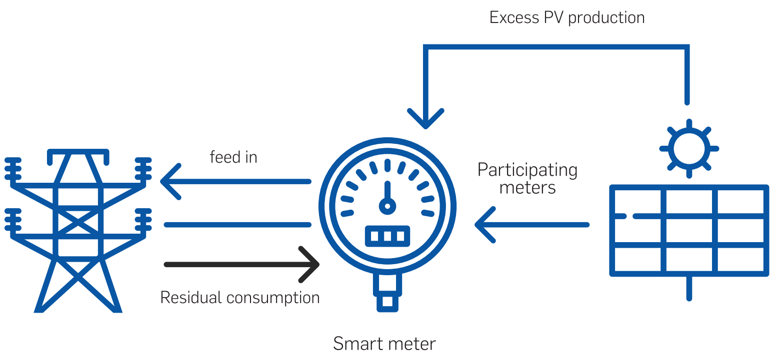
SolarCoin is already present in 41 countries and has been rewarded to over 1,620,000 MWh of solar power production on a test-basis, using the SolarCoin API and SolarCoin Raspberry Pi3 scripts available to all monitoring platforms, EPCs, inverter and datalogger companies. The aim of the SolarCoin project is to initiate the energy transition at a global scale. Join the SolarCoin network and trial our blockchain wallet application at www.solarcoin.org.



BLOCKCHAIN BOX

Blockchain distributed ledger technology could be used to account for solar electricity flows within a multi-occupancy building and smart contracts could help flats or occupiers automatically buy power when it is cheapest. This could be a new and better way of accounting for the power flows from rooftop to apartment or business unit, although added value would have to be proven compared to existing smart meter technology.

MIETERSTROM



Smart metering and digitalisation can also act as a catalyst for new solar PV business models in multi-occupancy buildings.

Multi-occupancy buildings – both residential and commercial – have historically been a more challenging market for solar PV than single occupancy buildings, due to barriers around the measuring and billing for solar-generated electricity consumed by different entities or flats in the building.

However with the advent of smart metering – and there are already 11 million smart meters across the EU - new business models have emerged.

A leading example of this in Europe is the 'tenant electricity' or 'Mieterstrom' model in Germany[13] . This is where a third party installs and owns a PV installation with a smart generation meter on an apartment block, and sells the electricity to participating apartments in the building through mini Power Purchase Agreements. The apartments must all have a smart meter and can either be owner occupied or rented. This model allows people who live or work in multi-occupancy buildings to also benefit from self-generated solar electricity and save on their energy bills, and it is made possible thanks to smart metering.

Other variants of this model include the collective self-consumption model in France[14] within which smart meters are mandatory and the shared generation facility model in Austria[15] . In France there are outstanding issues to be resolved regarding network charges and balancing responsible parties.

Finally, digitalisation also allows the implementation of mini power purchase agreements at the level of a single socket. An initiative in the United States called SunPort[16] has created a plug-in converter-style device which sources solar electricity for all consumption from that specific socket.

GRID-CONNECTED MICROGRIDS

Another business model that has emerged thanks to digitalisation is grid-connected microgrids [17]. Grid-connected microgrids can be used to reduce energy costs, source renewable electricity, provide back-up or uninterruptible power supply. They are made possible thanks to advanced microgrid management software platforms that optimise the different generation sources within the microgrid.

Leading consultants in this sector define a grid-connected microgrid as follows:
"A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can operate remotely, or connect and disconnect from the grid to enable it to operate in both grid-connected and island-mode."[18]

There is a considerable overlap between large (and especially commercial and industrial) self-consumption and the use of grid-connected microgrids, with the major difference being that grid-connected microgrids are also engineered to be able to provide back-up and continue operating during a grid power outage. This often involves the use of battery storage or gas or diesel generators.

The two major business opportunities for solar based grid-connected microgrids are industrial sites and municipalities. Both are geographically discrete areas, and in some countries like Germany municipalities often have their own distribution system operators.

(For off-grid microgrids, and especially those in the developing world, see box at end of report. These are not generally considered to be relevant in Europe, other than for the smallest and most remote islands.)

BLOCKCHAIN BOX

Blockchain technology is well suited to the management of flows within a grid-connected solar microgrid, determining when generation assets within the asset should be powered up or down. This technology can also if applicable govern transactions within the microgrid.

CASE STUDY:
SIEMENS: A MICROGRID GROWS IN BROOKLYN

The traditional centralised model of linear power generation and delivery through limited market or monopoly conditions is giving way, especially on a local level, to more diverse, dynamic, and complex systems with multiple actors and multilayered energy, information, and money flows. The changes towards these so-called Distributed Energy Systems are in response to renewable energy, smart technologies, and other new opportunities, as well as new policy goals – such as reducing emissions and extending energy access. To meet the respective project goals they can be customised to match the consumer's requirements as well as enabling actors to shape local generation and consumption in response to market price signals to achieve the lowest overall cost of energy.

LO3 Energy, a young New York company, is working with Siemens Digital Grid and Siemens' startup financer next47 to realise this approach with a microgrid in Brooklyn. There, neighbours with and without photovoltaic systems are buying and selling solar power from each other on a blockchain platform that automatically documents each transaction. The project is a pioneer in the movement towards a distributed energy supply system that draws on renewably-generated sources. On top of the above mentioned goals like emission reduction or small-scale trading of environmentally-friendly electricity, this solution enables self-sufficient operation in case of unexpected incidents in the public grid. To achieve this, the project plans to install battery storage units within the grid, which in combination with the local distributed generation and demand response solution will keep the lights on at least temporarily during the next storm-related emergency.

SIEMENS

Find out more about the Brooklyn microgrid:

Learn more about Siemens solutions for distributed energy systems and other relevant projects in this field:

PEER-TO-PEER: MAXIMISING THE VALUE OF EXCESS SOLAR ELECTRICITY

There is potential for peer-to-peer selling models to both increase the value of excess electricity – increase the selling price – and reduce costs for energy consumers.

We are likely to see a transition over the coming years from the traditional generator-retailer utility B2C business model to 'platform based business models' that facilitate prosumer-to-prosumer transactions. [19]

The major question then becomes whether and how such peer-to-peer platforms contribute to system costs and pay network charges, and what price is offered for the residual electricity. Some innovators have developed peer-to-peer network charges based on the actual distance between generator and consumer, thus incentivising local selling of electricity.

Another key question is how the platform business is remunerated for the service it provides. P2P platforms in other sectors have solved this with either subscription (e.g. pay monthly) models, transaction fee models or a basic service provided for free with a paid for premium upgrade. All of these could be applied in the electricity sector.

There is potential for peer-to-peer models to provide customers with value beyond an increased price for their power. For example, a P2P model might allow someone to give some of their excess solar electricity to members of their family or to local people living in energy poverty for free or a heavily discounted price.

It is important to note that the collective self-consumption model in France mentioned above is a form of peer-to- eer trading but with the requirement that the exchange has to happen within a single legal entity, such as a cooperative. Grid-connected microgrids can also contain peer-to-peer trading within them.

BLOCKCHAIN BOX

There is potential for the application of blockchain technology in peer-to-peer platforms. Blockchain works well as a platform for micro-transactions as it can reduce transaction costs, reduce barriers to entry and do away with traditional exchanges or intermediaries. This applies to not just trading between domestic households but also businesses and even larger installations. Transactions within the platform are administered and stored in a decentralised way, creating a secure system and inspiring trust. Smart contracts can fully automate the platform with settings that are pre-determined by the prosumer e.g. minimum sell price and maximum buy price. Some analysts claim that the IOTA Tangle blockchain or a private blockchain is more suited to energy trading than public blockchains as the transactions are processed faster.

MAPPING OF INDUSTRY PLAYERS IN THE 'DIGITAL SOLAR' SPACE

Smart buildings

- smappee
- centrica
- SMA
- BOSCH
- LOXONE
- LG

Digital O&M

- SunSniffer
- senseFly
- Solar-Log
- HUAWEI
- ALECTRIS – SOLAR ASSET CARE INNOVATION

Forecasting

- Reuniwatt
- Meteotest
- steadysun
- SOLARGIS
- Sheffield Solar

Digital manufacturing

- GE
- SOLIBRO
- Schneider Electric
- DSM
- First Solar
- Trinasolar

Microgrids & P2P

- StromDAO
- GreenSync
- ALPIQ
- LO3 ENERGY
- TOOMUCH.ENERGY
- sonnen

System design

- ezzingsolar
- SOLNET Green Energy
- openwatts VENTURES
- BayWa r.e. renewable energy
- GWAY energy

Digital utilities

- Eni
- innogy
- VATTENFALL
- e.on
- IBERDROLA
- EDF
- ENGIE
- enel Green Power
- TOTAL

Cross-cutting digital solar

- ABB – Power and productivity for a better world
- SIEMENS
- DNV·GL
- 3E

Mapping exercise conducted collaboratively by SolarPower Europe Digitalisation & Solar Task Force. This map is not considered to be exhaustive and some companies active in digital solar may not be represented. Equally, many companies are active in more than one of these areas so some simplification was required.

SECTION II: REDUCING COSTS AND INCREASING PERFORMANCE

Digital technologies can be used to reduce costs and increase performance at almost every point of the solar value chain. Here we look at three key segments of this value chain: module manufacturing, customer acquisition and installation design and operations & maintenance and asset management.

MODULE AND COMPONENT MANUFACTURING: CONNECTED FACTORIES OF THE FUTURE

Equipment and module manufacturers have long used robotics and other digital technology to increase accuracy and reduce costs in solar manufacturing. Robotisation is relevant for the wider digitalisation of the sector as it allows the collection of data on processes and efficiencies. In the future there is potential for connected machines and advanced data analytics to further reduce the cost of PV value chain manufacturing.

Advanced monitoring technology also helps reduce to a minimum the risk of exposure from raw materials and chemicals used in PV manufacturing processes and also enables far higher standards of quality control. Further down the production process, automation has allowed for in-depth quality checks of individual cells and modules.

Many equipment manufacturers already have advanced systems for monitoring the performance and efficiency of individual cell and module production lines. Other players are seeing more and more demand from clients for equipment to be able to communicate with other machines and components in the factory and with a central SCADA communications system. This could allow for the application of predictive maintenance to solar manufacturing equipment. Clients also want equipment to be more flexible and future-ready, able to adapt to future digital innovations in manufacturing processes.

In the same way that solar digital operations & maintenance is seeing the emergence of 'digital field workers' some product manufacturers are implementing 'digital factory workers', with information systems that allow staff to improve the accuracy and quality of their work. This could in the future even be done not through company-provided equipment but a bring-your-own-device program to allow for a seamless user experience.

In certain niche PV markets there is also potential for more mass personalisation in solar manufacturing, where wholesalers, end users or architects could order custom-made parts from manufacturers. This is very unlikely to apply to mass manufactured standard PV but could be viable with smaller niche products. This is an example of digital technology permitting the consumerisation of B2B activity. This could involve specific requirements in terms of module shape, bifacial features, or materials that are adapted to low irradiance or high temperature conditions. This could also be applied to building integrated, organic, glass and transparent PV. In glass-based PV customers are already ordering product 'to spec'.

In the future it is also possible that 3D printing could be used to manufacture both whole modules and spare parts more cheaply and easily and closer to site. Some manufacturers are investing R&D into 3D printing, although many commentators believe this is still a long way off. This is particularly relevant to spare parts for discontinued models and production lines.

WHAT DOES DIGITALISATION AND ROBOTISATION MEAN FOR SOLAR JOBS?

As all sectors of the economy transition to industry 4.0 and more digital operations it is clear that the issue of the robotisation of work and the potential related reduction in low-skilled labour in the upstream segment of the solar value chain needs to be addressed. It is estimated that new technology could lead to time savings of five to eight hours of work per week per person across the energy value chain[21] . However experience in the solar sector has shown that low-skilled jobs are often replaced with high-skilled jobs, as staff are required to design, maintain and operate the equipment. The solar PV sector is nonetheless different to many other sectors of the economy due to its high growth potential in Europe and around the world. The entire value chain is currently estimated to employ 110,000 full-time equivalents in Europe [22] , and this is projected to increase if and when deployment increases. PV – and especially roof-mounted applications – is very job-intensive when compared to other renewable and conventional energy technologies and creates highly localised jobs. It has been estimated that solar has a jobs intensity of around 20 full time equivalents per MW for rooftop installations and 7 full time equivalents per MW for utility-scale, both relatively high compared to other renewable technologies. [23]

CASE STUDY:
SMA BENEFITS FROM WORKER INFORMATION SYSTEM IN MANUFACTURING PROCESS

One of the global mega trends is digitisation and this trend is also taking effect within SMA. Innovative system solutions fulfill the digital requirements of the energy industry and based on digital energy services brand new business models are developing. Digitisation has long found its way into the manufacturing process as well. In 2015, SMA implemented the Worker Information System (WIS) in its central inverter production, with the goal of creating a more flexible and efficient production process. By using the WIS, SMA can increase product quality, product safety, the safety at site and is well-prepared for audits.

All information relevant for the production process is distributed via the Worker Information System and the workflows are controlled by it. Employees now use a visual representation on a console instead of printed mounting instructions. The WIS guides SMA staff through the individual assembly phases and ensures that all materials are installed, wired and inspected in the pre-specified order and with the correct torques. Image by image, the worker learns what needs to be done. This lightens the worker's load when dealing with sensitive, complex or varied components. Additionally, workers can be used in a more flexible way at the different individual assembly stations because they can be quickly trained at each workstation thanks to the system's role as a virtual assistant. Production errors are prevented and process flows ensured.

All installed materials are entered in a SAP software solution once an assembly step has been completed. The SAP materials management interface ensures that the right material is available in sufficient quantities at all times. In addition, the data captured during the process flow is saved in the digital test report of the device. This way, customers and other SMA services can always view the product's components. This shortens the response time if repair work is needed. Introducing the WIS has paid off for SMA: the lead time in production has shortened and the product quality increased. This is why SMA is planning to use the WIS at additional production sites to further increase productivity. The digital screw system that has been running in parallel until now is also to be connected to the WIS. SMA's fleet of digital factories is thus steadily expanding.

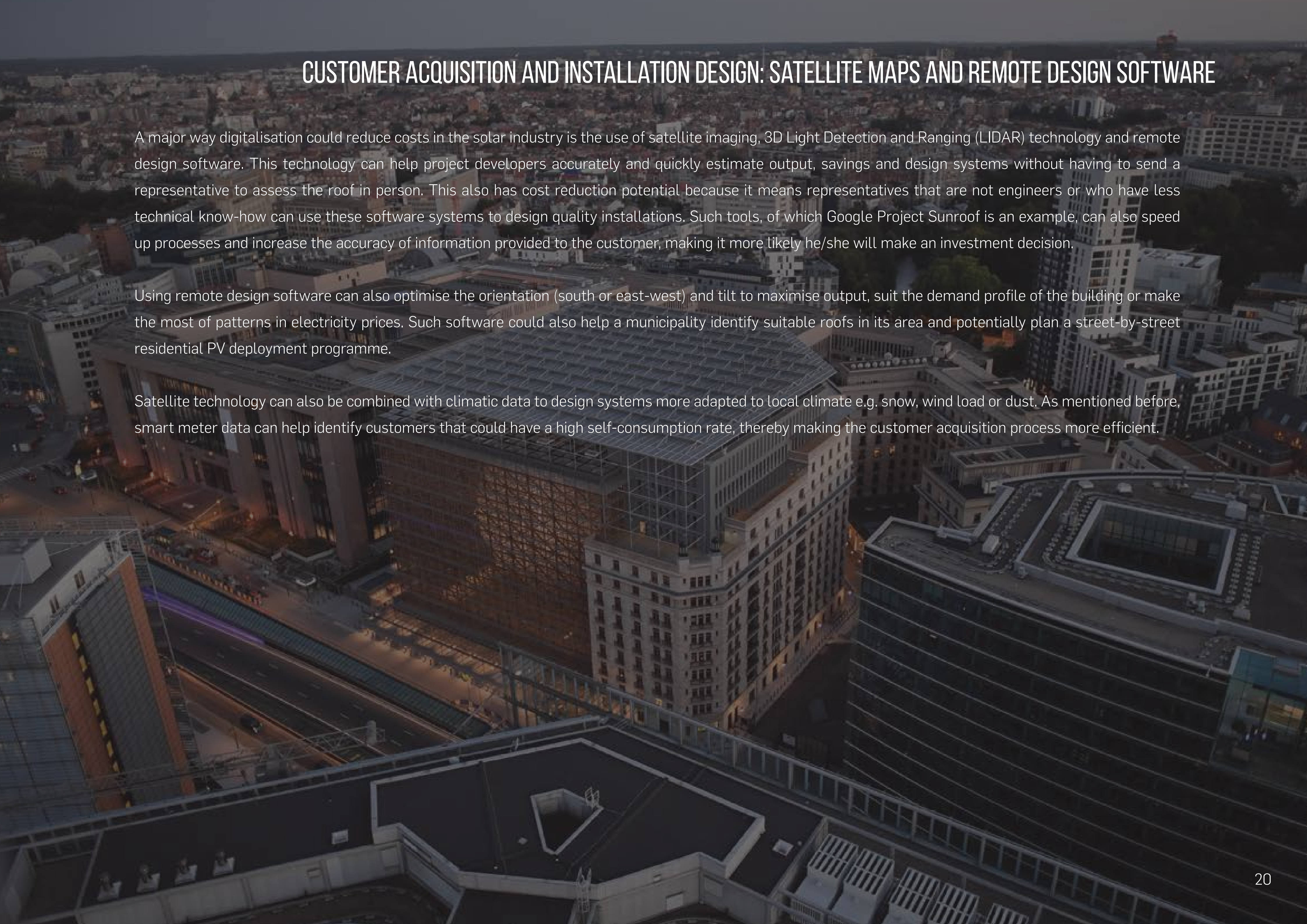
SMA

CUSTOMER ACQUISITION AND INSTALLATION DESIGN: SATELLITE MAPS AND REMOTE DESIGN SOFTWARE

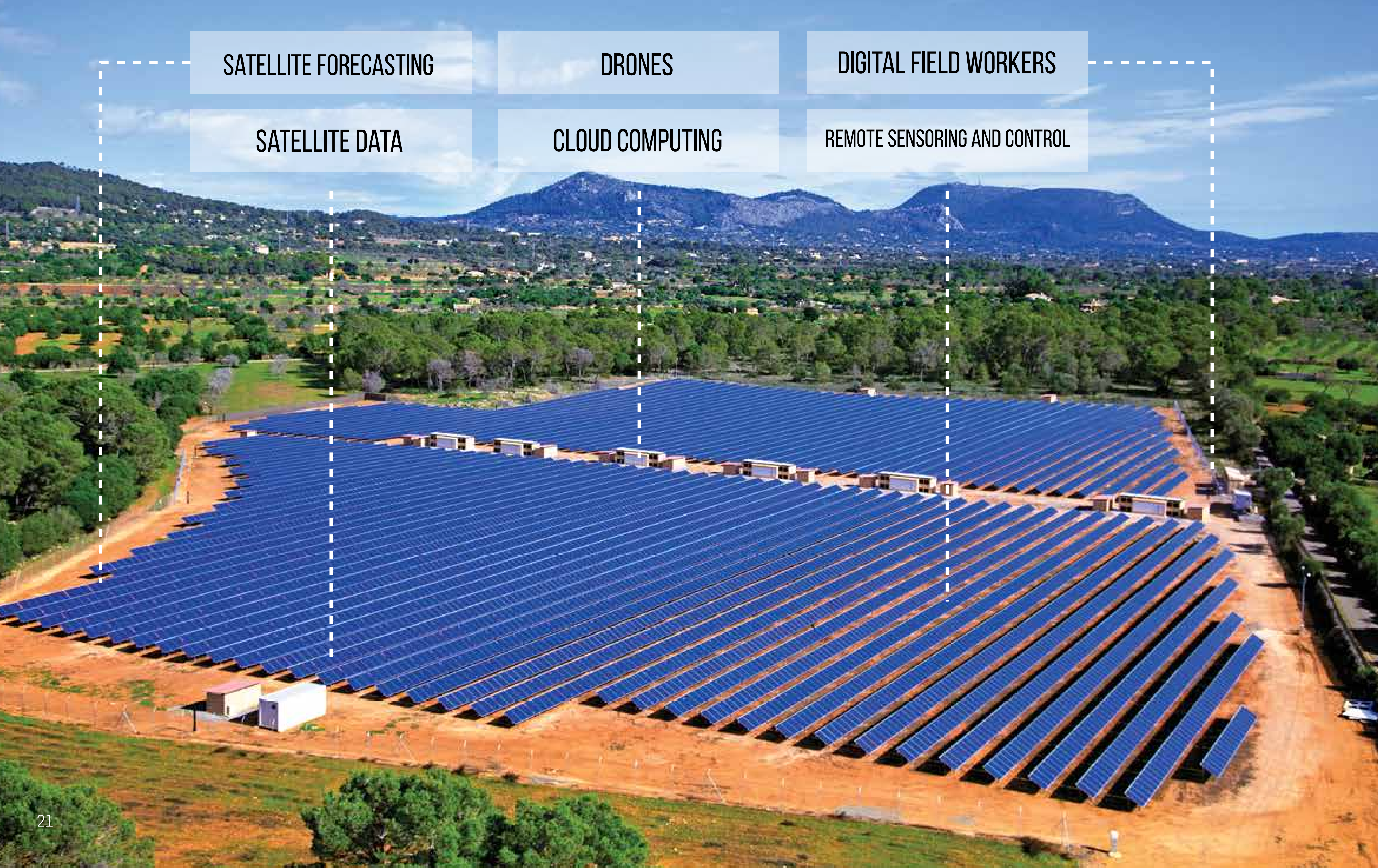
A major way digitalisation could reduce costs in the solar industry is the use of satellite imaging, 3D Light Detection and Ranging (LIDAR) technology and remote design software. This technology can help project developers accurately and quickly estimate output, savings and design systems without having to send a representative to assess the roof in person. This also has cost reduction potential because it means representatives that are not engineers or who have less technical know-how can use these software systems to design quality installations. Such tools, of which Google Project Sunroof is an example, can also speed up processes and increase the accuracy of information provided to the customer, making it more likely he/she will make an investment decision.

Using remote design software can also optimise the orientation (south or east-west) and tilt to maximise output, suit the demand profile of the building or make the most of patterns in electricity prices. Such software could also help a municipality identify suitable roofs in its area and potentially plan a street-by-street residential PV deployment programme.

Satellite technology can also be combined with climatic data to design systems more adapted to local climate e.g. snow, wind load or dust. As mentioned before, smart meter data can help identify customers that could have a high self-consumption rate, thereby making the customer acquisition process more efficient.



DIGITAL OPERATIONS &MAINTENANCE (O&M) AND ASSET MANAGEMENT



Digital technology can also be used, particularly in large-scale utility ground-mounted solar, to reduce operational costs and increase asset performance. The solar O&M sector is already highly digitalised, but of course new digital technologies become viable as their costs decrease.

Monitoring systems already measure and process a huge amount of data from large-scale solar plants: energy meter data, irradiance, module temperatures, weather data, string level monitoring and AC and DC side inverter measurements. As technologies mature only data that can generate real value and be monetised will be collected, thereby reducing the data collection costs and making processes more efficient.

Advanced software is also used in the management of operational data: interventions, reaction and resolution times, event types, final diagnosis of cause and cost of interventions (both in terms of labour and materials). This data is used to optimise the operation of the asset at least cost.

- Improved asset lifecycle management can be done with major industrial connectivity platforms to leverage big data and increase efficiencies. Digital engineering can be used to model and simulate systems. Data can be analysed at portfolio level, plant level, inverter level, string and module level. A benchmarking of these industrial data platforms would be useful moving forwards.
- Predictive maintenance can use patterns in temperature and output to predict module degradation, soiling, component (e.g. module, inverter or combiner boxes) failures or system failures. This could eliminate some maintenance visits, anticipate others and reduce expensive unplanned emergency visits.
- Remote sensoring and control, 5G and wireless communications, embedded test electronics and data analysis can help diagnose faults remotely, enhance preventative maintenance and increase plant yield. At present most solar data is communicated using a normal interconnection DSL and LAN with GPRS as back-up. Low-power wide-area networks (LPWAN) may be used in future, which is also enabling a lot of IoT communications.
- Cloud computing is used to store data from data loggers on site.[24] Note that an International Electrotechnical Commission (IEC) or similar international standard is currently missing in this area, and more work is therefore needed in this area especially with regards the savings that can be generated.
- Digital field workers who use mobile technology can make field operations more efficient, and central control centres can track the locations of teams to assign them to jobs in an optimised manner. The more data field workers input into systems in real-time the better the reporting on response times can be and the better the analysis of improvements in performance. Smart glasses technology could even be used in future to assist in maintenance.
- Drones can be used to do visual imaging of modules, wiring and other plant components and infrared thermal imaging monitoring. In future drones may have their own on-board data analytics capabilities to detect patterns and change.
- Satellite forecasting for irradiance measurements and remote sensing is now considered best practice. Forecasting also allows for better-timed maintenance visits and can be compared with real measurement data to further improve forecasting. Satellite-based data services are accurate across the year and are less prone to systemic errors. Looking ahead we are likely to see more and more granularity in satellite data e.g. 15 minute intervals. Similar technology can also be used to track dust, pollution and particulate matter that impacts yield.
- 3D printing could, in the future, reduce spare parts management costs by reducing the number of spare parts in storage, decrease lead times and manufacture spare parts closer to site.

As far as small-scale systems are concerned, this has been in the past an application segment with minimal if any routine monitoring and O&M. However as digitalisation and low cost computing helps reduce the cost of O&M, it can make O&M more viable in this segment. This applies to both new installations and the retrofitting of monitoring on existing installations (retrofitting is particularly economic on legacy systems with high Feed-in Tariffs). Potential benefits include higher yield due to the detection of dust on modules and immediate alerts when components malfunction.

Many different providers are now offering monitoring solutions for small-scale and residential systems. One of the possibly functions of small-scale building energy management systems could also be the detection of faults and irregularities in the PV system. According to leading consultants, global cumulative revenue for the residential solar monitoring market between 2017 and 2026 is expected to reach $5.4 billion, monitoring up to 40 million individual residential systems[25]. This figure includes diagnostic analytics and hardware, but not home visits and repairs, which could add another $2 billion per year by 2026. In the future there is potential to use cloud computing and big data analytics to not just monitor but also act on the data, such as recommending power diverters or aggregating the PV installation with others to gain new revenues from grid services.

CASE STUDY:
ALECTRIS: APPLICATION OF ACTIS TO OPTIMISE UNDERPERFORMING BIAXIAL TRACKING PLANTS

ALECTRIS
SOLAR ASSET CARE INNOVATION.SM

Commitment four of the Solar Industry's Seven Commitments on Digitalisation (see below) addresses reducing costs. It relates to solar operations and maintenance to increase system availability and reliability. Alectris started developing the world's first solar Enterprise Resource Planning (ERP) digital industrial platform in 2011 and launched it in the market in 2013. ACTIS delivers an integrated platform of solar investor and plant owner system management benefits. ACTIS has been used from the very beginning by the Alectris operations team and in numerous case studies it has been the digital tool to determine system failures, validate optimisation results and manage maintenance and operations. Biaxial solar photovoltaic (PV) trackers, for example, are technically complex and more difficult to operate and maintain than fixed tracker plants. These plants can suffer from:

- control software not designed and implemented to ensure optimum sun tracking;
- lack of monitoring and manual checks which lead to substantial downtime;
- frequent mechanical damage due to design errors or external causes.

Alectris will diagnose, propose solutions and then engineer and implement the solutions to transform underperforming plants into sites optimised for performance. Alectris will study and propose an action plan generally along the following parameters:

- an intermediate solution to keep the trackers running at the maximum of their capabilities;
- studying in detail the deficiencies of the construction and control software;
- suggest the most suitable maintenance plan;
- monitor the operation of the trackers, intervene in case of failures and suggest a spare part stock based on the statistics of maintenance activities.

Consistently Alectris revamps biaxial tracker plants and creates strong results including:

- additional generated energy up to 20-25% even during the winter period;
- implementation of the tested solution within short deployment schedules;
- proper control and monitoring by integrating the tracker control system software into ACTIS.

CASE STUDY:
BAYWA R.E.'S INFRARED (IR) INSPECTIONS WITH DRONES TO IMPROVE PERFORMANCE ANALYSIS

As a leading global provider of operation and maintenance services, BayWa r.e. is heavily investing in digitalisation to improve the operational performance of the plants it manages and to reduce maintenance costs.

The participation of BayWa r.e. Operation Services S.r.l., BayWa r.e.'s Italian business, to the "Solar Train" project (funded by the European Union's Horizon 2020 program), illustrates this commitment. The project is aimed at combining the two megatrends of renewable energy and big data and is already helping to inform BayWa r.e.'s own digitalisation strategy.

Among the strategy's objectives is the ambitious task of being able to fully utilise and apply the millions of pieces of data available within the company's monitoring systems, to design new predictive maintenance strategies and optimise energy performance.

The project started with the joint effort of researchers who study plant performances applying data mining software, and engineers that are developing new on site measuring methodologies. One output has been the use of drones for aerial infrared thermal imaging analysis. The drone is very efficient, especially if larger areas with many modules have to be inspected or in plants installed on roofs or greenhouses. But to make the process really useful, it has to be managed in a proper manner and specific post-production software is required. Starting from 2017, BayWa r.e. has adopted drone thermography as its standard method for fast and precise analysis of module failures. Through this methodology, BayWa r.e. is significantly improving the capability to correlate infrared inspection results with performance data to take efficient maintenance decisions. A further development is the overlapping of geo-referenced thermographic images to GIS software and comparing them year-on- year to support predictive maintenance strategies.

In multiple cases, the joint analysis of monitoring software data at string level and IR inspection outcomes has made it possible to make sound decisions on module substitution that have assisted the client in claims against module manufacturers.

BayWa r.e.
renewable energy

SECTION III: DIGITAL GRID INTEGRATION

Digitalisation can also be a means to integrate more variable renewable energy (such as solar and wind) into the grid and achieve system-wide benefits. This allows for a higher share of renewables in the system than would have been possible without the implementation of smart technology. EY defines a digital or smart grid and its main aims as follows[26] :

"A 'digital grid' is a digitised electricity grid that makes use of new technology such as sensors, wireless communications and big data analytics to remotely monitor, control and automate the network. The aim of a digital grid is to improve reliability, availability and efficiency of the grid while better managing increased distributed generation."

BETTER MATCHING SUPPLY AND DEMAND WITH SMART GRIDS

Big data and cloud analytics can allow for better predictions and real-time management of grid load, better matching of supply and demand and therefore higher shares of variable renewables such as wind and solar.

Smart grids with digitally-enabled demand response and additional storage could by 2040 reduce curtailment of solar PV and wind across the EU from 7% to 1.6% and avoid 30 Mt of CO_2 emissions annually, according to the International Energy Agency. European Commission modelling, as described in its impact assessment on downstream flexibility, has shown that a peak decrease of 36GW in 2030 will lead to €1,383 million per year in benefits for the distribution and transmission grid and €3,772 million per year in reduced back-up capacity.

Combining solar with behind the meter and large-scale energy storage can allow for the best use of zero marginal cost solar electricity when it is readily available and optimised injection into the grid. Grid optimised storage decreases feed-in capacity which in turn can increase local grid capacity by 66%[27] . Aachen University analysis of the KfW programme for solar and storage in Germany has shown that about 165 GWh of self-consumed electricity has reduced feed-in tariff expenditure by €21.4million. The study also found that a combination of solar and grid supporting storage can double the grid capacity to absorb PV feed-in without any other additional infrastructure. This is a major systemic opportunity for solar as it allows for more PV to be integrated into the grid without expensive grid reinforcements.

Better remote monitoring and control can lead to real-time load balancing, and up-to-the-minute pricing signals and tariffs will allow customers to better respond to price signals and create a more flexible electricity grid, better suited to variable generation.[28] Intelligent devices and sensors in the grid could create $18 billion of value for the energy system as a whole and customers could save $290 billion from lower peak consumption over the next 10 years. There have been over 450 smart grid projects in Europe to date, totalling €3.5billion of investment. Many of these have started at neighbourhood or city level, allowing for more local optimisation and balancing.

BLOCKCHAIN BOX

With Blockchain distributed ledger technology you can attribute demand to specific consumers down to five minute intervals or even a minute-by- minute basis, logging when, where and by whom the electricity is generated. This could help optimise network operations at distribution and transmission level. Blockchain technology, especially when coupled with artificial intelligence technology, could simplify or eliminate the clearing process, which is the reconciliation of forecasted or planned consumption against customers' actual consumption as recorded by their meters. Supply and demand could be balanced with smart blockchain contracts within microgrids, virtual power plants, and the balancing market.

CASE STUDY:
ALPIQ'S TURN-KEY GRIDSENSE ENERGY SERVICES WITH SOLAR PV, BATTERY STORAGE, HEAT AND E-MOBILITY

GridSense is Swiss company Alpiq's smart technology of the future. It controls electrical equipment such as heat pumps, boilers, electric car charging stations and batteries autonomously and in a decentralised way. GridSense uses adaptive intelligence to gauge, learn and anticipate user behaviour. It is equipped with a self-learning algorithm that controls building technology appliances as effectively as possible. It uses this information to ensure constantly optimised energy consumption within a building. With this Alpiq technology, a conventional house is transformed into an energy-efficient smart building. Through intelligent switching of loads, GridSense also contributes to the development of a smart grid, thus helping to level out grid load. With GridSense, Alpiq offers turn-key energy services for utilities, from solar PV to heat and e- mobility. It allows energy service providers to retain their customers on a long-term basis with tie-in deals and increase their added value with the sale of GridSense technology. Due to improved client information, users are able to shape the customer relationship more efficiently and optimise processes.

Turn-key energy services for your customers

With GridSense you offer managed solar PV, battery storage, e-mobility and heating to your end customers. Long term contracts can be concluded and there is high potential for additional online selling.

Full transparency of energy consumption information and smarthome integration

GridSense enables utilities to give their customers a detailed and fully transparent picture of their consumption data. The system boosts and extends smart home systems to an integrated solution with full energy management functions and creates added value with energy services.

Predictable energy consumption and cost optimisation

Thanks to GridSense forecasting, utilities are able to plan their future energy sales more precisely and optimise their purchasing of energy in the market.

ALPIQ

Interested in offering GridSense as a turn-key energy service? Contact Ralf Gazda on ralf.gazda@alpiq.com.

NOWCASTING AND FORECASTING

More distributed solar PV generation can be integrated into the grid with accurate, real-time generation and forecast data that can be made available to network operators such as DSOs and TSOs. Accurate forecast data can also increase revenues for asset owners, O&M providers, solar plus storage operators, traders and aggregators, allowing them to minimise their balancing costs. The significant increase in solar installation data over the last few years has in turn allowed forecasting to become even more accurate.

Thanks to computer-modelled weather forecasting, satellite and sky imaging technologies (all leveraged by big data analytics), self-learning and image processing through cloud computing, forecasts can be delivered from the next minute up to several days on areas spanning from a couple to tens of kilometers.

Data exchanges between solar PV providers and TSOs can potentially act as a new revenue stream for solar forecasters and aggregators, and can generate significant operational savings for TSOs.

Looking ahead the key technological advance that will further enable this sector is that of communications to remote sites. As described in the digital O&M section above, at present most solar data is communicated using a normal DSL or LAN internet connection with mobile GPRS connections as back-up. Low-power wide-area networks (LPWAN) may be used in future. Much depends on what is available at the site and what communications infrastructure the asset owner has decided to put in place. Similarly, improved camera cloud cover imaging, which can then be analysed and translated into irradiation forecasts, could also increase accuracy in this area.

NEW REVENUES FOR GRID SERVICES

With advanced power electronics solar PV is a highly controllable power source that can provide a number of services to the grid – and be remunerated for those services. This applies to both large-scale solar plants and small building-mounted plants.

Examples of grid services which solar can be remunerated for include reactive power, voltage support and frequency support. Note that this does often require these markets to be reformed so that the incentives match what solar PV can offer – some countries have such long lead times and high penalties that it can make it impossible for a solar installation to participate.

For small-scale PV, building energy management systems and energy management gateways can be used as a gateway for providing these grid services through aggregators and new sources of revenue. By pooling distributed resources and meeting minimum bid sizes, aggregators can unlock new sources of revenue in balancing markets and elsewhere. Smart building energy management systems can also help manage grid congestion by controlling in-feed to the grid at critical times.

Inverters can be thought of as shock absorbers or handbrakes for the grid that can help regulate frequency. The ability to dynamically control solar inverters and issue real-time commands with extremely fast response times means that solar can provide very accurate grid services. It has been proven that solar can in some cases provide grid services with more accuracy than conventional power generators.

It is even possible to use inverters to provide services at night. Pilot projects in the UK and the United States have shown that it is possible to use inverters as capacitor batteries for voltage control at night, eliminating investment in other voltage control devices.

BOX: BEYOND EUROPE'S BORDERS

The geographical scope of this report has broadly been restricted to Europe with digitalisation case studies relevant to the European market from around the world e.g. USA and Australia. Additional work is needed to assess the potential for the digitalisation of solar outside of the EU in new and emerging markets around the world. Solar-based off-grid microgrids are being developed in areas that do not currently have access to electricity and entrepreneurs are frog-leaping traditional technologies and moving straight to new digital solutions such as blockchain. Mobile money technology is enabling pay-as-you-go pico home solar solutions. Additional research and analysis is clearly required in this area. Interesting case studies of digitaliation in developing world solar include the MasarBox mobile solar containers, Engie's PowerCorner microgrids, the Amigo Solar in Chile, Electraseed blockchain microgrids, MPAYG's use of pay-as- you-go solar and Sunexchange's Bitcoin-enabled crowdfunding for developing countries.

THE SOLAR INDUSTRY'S SEVEN COMMITMENTS ON DIGITALISATION

In May 2017 the SolarPower Europe Digitalisation & Solar Task Force published its "Seven commitments on digitalisation" to aid the transition to fully digitalised solar. They were:

1. **Prosumer choice:** We will promote transparency and choice for prosumers in particular encouraging mechanisms for easy switching from one product, platform or aggregator, to another.

2. **Peer-to- peer exchanges:** We will support decentralised peer-to- peer energy exchanges and explore innovative solutions, such as blockchain technology.

3. **Smart and stable grids:** We will collaborate closely with network operators to build smart and stable grids that include solar, storage and flexible demand. These grids will use real-time data to optimise electricity generation and demand. This will also allow the system to maximise the market-based ancillary services that inverters can provide and be remunerated for, such as reactive power and frequency response.

4. **Reducing costs:** We will use digitalisation to make solar more cost-effective both in terms of up-front costs and levelised cost of electricity (LCOE) and increase system availability and reliability, thus enhancing the competitiveness of solar.

5. **Interoperability:** We will encourage the interoperability of software with compatible hardware, to enable the transfer and sharing of data that is both secure and efficient

6. **Data protection and cybersecurity:** We will champion data protection and recommend that all companies active in the solar industry implement state-of- the-art data protection, in-line with established EU-wide principles 29 . We will put inplace stringent cybersecurity measures.

7. **Sharing excellence:** We will endeavour to share digitalisation excellence, gathered within the European industry with the rest of the world, with specific emphasis on supporting the developing world.

These commitments were coordinated by Huawei Solar on behalf of the SolarPower Europe Digitalisation and Solar Task Force.

SOLARPOWER EUROPE'S REGULATORY ASKS ON SOLAR AND DIGITALISATION

In June 2017 the SolarPower Europe Digitalisation & Solar Task Force published its "Regulatory asks on solar and digitalisation" to set out what policy changes are needed at national and EU level to promote the digitalisation of the sector. They were:

1. Remove barriers to the **peer-to-peer trading of electricity,** such as (but not exclusively) supply license requirements, concluding contracts between peers, network charging and existing and future systems for the delivery and billing of electricity.

2. Ensure that the implementation of regulation does not preclude **new technologies and business models** for the trading of and accounting for electricity, such as blockchain and cryptocurrencies that create incentives for PV and enable prosumers to participate in energy markets.

3. Encourage regulation that allows **aggregators** to compete with conventional generators in all electricity markets and offer services in these markets via new or different digital technologies, such as Virtual Power Plants. Allow aggregators to combine resources from all voltage levels and use appropriate measuring equipment for the size of the installation.

4. Use digitalisation to develop **flexibility markets with more automated tools** and standardised products, as well as standardised requirements for the provision of system services both behind the meter and at distribution and transmission level. Reform intraday and spot-markets to enable large-scale solar and solar-plus- storage plants to take on balancing responsibilities.

5. Accelerate the deployment of **smart grid** technology, so that more solar can be integrated into the system and both utility-scale and small-scale solar can provide services to the grid. In conjunction, reform incentives for network operators, to encourage them to implement smart grid technology as an alternative to strengthening cables and transformers. Also provide more funding to smart grid and smart market integration projects such as within the Connecting Europe Facility funding instrument.

6. Reward the speed and accuracy that distributed energy resources such as solar and storage can provide in terms of **grid support services.**

7. Accelerate the deployment of **smart metering** functionality, real-time measurement of consumption and grid feed-in, as smart metering is a catalyst for new solar business models. Ensure that consumers have access to their smart meter data and guarantee that the roll-out of smart meters will not discriminate against new and existing innovative solutions and solar prosumers. Avoid imposing extra costs on smart meter customers, or mandating a single gateway for all energy data in and out of a building. Ensure that self-consumed electricity is not subject to taxes, fees or charges.

8. Ensure that proposals within the market design package for metering and consumption **data** to be made available between DSOs, TSOs, customers, suppliers, aggregators and energy service companies are maintained. Guarantee that state of the art and up-to- date data protection and cybersecurity standards are put in place.

9. Maintain provisions in the proposed revision of the Energy Performance of Buildings Directive on a **'smartness indicator'** for homes and ensure that on-site electricity generation is given a bonus within the methodology for setting cost- optimal minimum energy performance requirements for new and renovated buildings. Ensure that this methodology takes a holistic view of sector coupling, so that excess PV electricity can be used and stored e.g. as heat via heat pumps, or hot water storage.

10. Ensure that EU-level work on **standards and interoperability**, within the Digital Single Market includes solar PV systems, smart buildings and smart grids. Encourage the Commission to come forward with its 'baseline' standardised data format as soon as possible, which individual device or service manufacturers will then add additional features to.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The SolarPower Europe Digitalisation & Solar Task Force started its work in December 2016 and has had regular meetings and calls since.

Please get in touch with SolarPower Europe if you have any comments or feedback on the report and its content in order to enrich our ongoing work in this field.

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Task Force coordinator and lead author of report: Sonia Dunlop, Policy Adviser, SolarPower Europe.

If you would like more information on the contents of this report or on the work of SolarPower Europe please contact info@solarpowereurope.org or call +32-2- 709-55- 20.

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21 World Economic Forum/Accenture (2016) Digital transformation of industries: Electricity industry, p. 11. Available here:

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https://www.accenture.com/t20170116T084450__w__/us-en/_acnmedia/Accenture/Conversion- Assets/WEF/PDF/Accenture-Electricity- Industry.pdf. 29 As defined in Article 5 of the EU General Data Protection Regulation, available here: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679&qid=1491311160002&from=en

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